Scientific Research Publishing

World Journal of Engineering and Technology, 2025, 13(2), 393-401
https://www.scirp.org/journal/wjet
ISSN Online: 2331-4249
ISSN Print: 2331-4222

Proposal for an Experiment to Confirm the Existence of Branching Universes

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How to cite this paper: Yasukagawa, M. (2025) Proposal for an Experiment to Confirm the Existence of Branching Universes. *World Journal of Engineering and Technology*, **13**, 393-401.
https://doi.org/10.4236/wjet.2025.132024

Received: March 26, 2025
Accepted: May 26, 2025
Published: May 29, 2025

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Abstract

In quantum mechanics, besides the Copenhagen interpretation where the wave function collapses upon observation to yield a single measurement value, there is the many-worlds interpretation initiated by Everett. If this many-worlds interpretation is correct, it implies that the real world splits into many, leading to the existence of so-called branching universes (parallel universes). Traditionally, it has been considered impossible to prove this existence, but I have discovered that it can logically be demonstrated by conducting experiments like the ones outlined below. Therefore, in order to deepen our understanding of the universe, I would like to have individuals with the necessary technology and knowledge carry out this experiment to prove the existence of branching universes.

Keywords

Many-Worlds Interpretation, Non-Local Long-Distance Interactions (Quantum Entanglement), Bell's Inequalities, Double-Slit Experiment

1. Introduction

The existence of non-local long-range interactions has been proven in Wheeler's delayed choice experiment [1] and Alain Aspect's violations of Bell's inequalities [2] [3], as well as in many studies [4]-[7]. This phenomenon allows for the creation of pairs of photons using devices (down-converters) that convert high-frequency light signals to lower frequencies, such as barium borate, a nonlinear crystal that realizes semi-reflective mirrors and optical parametric oscillation, whereby the behavior of one photon influences the other photon located far away. I would like to propose an experimental method to demonstrate the real existence of branching universes.

2. Points of the Copenhagen Interpretation

The Copenhagen interpretation is the mainstream interpretation of quantum mechanics proposed by Niels Bohr and Werner Heisenberg in the 1920s.

1) Quantum states can only be determined probabilistically.

The state of a particle is described by a "wave function", and until it is observed, it exists only as a probability.

2) The wave function collapses upon observation. Until observation, an electron holds "multiple possibilities," but at the moment of observation, it converges to a single outcome.

3) It cannot be said to be "existing" until it is observed. For example, an electron in the state "having passed through slit A" and the state "having passed through slit B" are in superposition, and until observation, it is undetermined which slit it has passed through.

According to the formulation made by Von Neumann in 1932, quantum systems and observers (measurement devices) are separated. The two boundaries can be drawn anywhere. The state of a quantum system follows the Schrödinger

$$i\hbar\frac{\partial}{\partial t}\psi(\boldsymbol{r},t)=\left(-\frac{\hbar^2}{2m}\nabla^2+V(\boldsymbol{r})\right)\psi(\boldsymbol{r},t)$$

equation below when not being observed. Observation causes the wave function to collapse, resulting in one measurement value. Which measurement value is obtained is probabilistic and follows Born's rule.

3. Points of the Many-Worlds

Interpretation based on the formulation proposed by Hugh Everett III, a graduate student at Princeton University, in 1957.

1) The wave function does not collapse upon observation, instead of simply selecting one possibility at the moment of observation, it is considered that "all possibilities continue to exist in parallel".

2) The universe branches with each observation. For example, both "the world through slit A" and "the world through slit B" exist, and the observer also branches into each world.

3) Quantum mechanics progresses deterministically. It is not determined by probability; rather, all possibilities actually occur and simply branch into separate worlds.

4. Bell's Inequality

Measurements are taken at two different locations, A and B. The measurements yield only two results, +1 or −1. The measurement devices at A and B each have two settings, which are randomly switched for each measurement to measure the corresponding physical quantity. In the measurement at A, either physical quantity A_0 or A_1 is measured, and in the measurement at B, either physical quantity B_0 or B_1 is measured, with both measurement values being +1 or −1. Under local

realism,

$$|S| \le 2$$

$$S = (A_0 B_0) + (A_0 B_1) + (A_1 B_0) - (A_1 B_1)$$

but in the experiment, S exceeded 2, confirming the violation of this inequality.

Many studies related to the violation of such Bell's inequalities have been published [8]-[15].

5. Quantum Entanglement

A phenomenon proven by the violation of Bell's inequalities, occurs when two quantum systems are in a state that cannot be separated from one another. When one quantum takes a specific state, that information is instantaneously transmitted to the other, solidifying its state. As long as they remain in that quantum entangled state, they will continue to have a correlation regardless of the distance between them. New technology development is underway utilizing particles in such a quantum entangled state [16] [17].

1) Quantum Computers. The existence of quantum entanglement has been clarified, and various quantum technologies such as quantum communication and quantum sensing are being researched worldwide, particularly quantum computers. These allow for high-speed computational processing compared to digital computers by utilizing phenomena like quantum superposition and quantum entanglement [18].

2) Cryptographic Communication Using Quantum Entanglement. In addition to quantum computers, there is also utilization in communication. Photons in a quantum entangled state instantaneously determine the state of one another even when they are far apart, by measuring one. By combining this property with classical communication, it is possible to achieve "quantum teleportation" to transfer quantum states, which can be applied to quantum communication.

In theory, quantum communication is possible regardless of how far apart the parties are, and since there is no worry about interception or eavesdropping like with normal communication, secure communication becomes feasible [19].

3) This research paper demonstrates that the phenomenon of quantum entanglement can be used not only in the microscopic world but also in the macroscopic world, specifically as a method to determine whether the entire universe is a multiverse.

6. Quantum Interference Fringes

As is known from the debate between Einstein and Bohr, performing a double-slit experiment with quanta such as electron beams produces interference patterns on the screen, and this interference pattern demonstrates the wave-particle duality since the same result is obtained even when electrons are emitted one at a time. However, it has been proven that this interference pattern disappears if the paths of the particles can be identified through observation [20] [21].

The condition for the bright line to occur when the position of x is denoted as x_m for an integer m based on Young's experiment is as follows: $d/L \cdot x_m = m\lambda$ $(m = 0, \pm 1, \pm 2, \cdots)$.

Where d is the distance between the light sources, L is the distance between the downconverter and the screen, and λ is the wavelength of the light.

Experimental method

It is possible to generate photons in a quantum entangled state {22}, and by attempting experiments, it has been confirmed that the results influence not only the tiny quantum world but the entire universe, confirming the existence of branching universes.

Experiment 1

When the light source is weakened and photons are emitted one by one, as shown in Figure 1, each photon either follows the upper solid line path or is reflected by the half-silvered mirror to take the lower dashed line path. After the branching, each photon probabilistically takes one of the paths, and which path it will take remains uncertain. Therefore, after being divided into two entangled photons in a quantum state with half the frequency through the down-converters (1) and (2) using nonlinear optical crystals such as lithium niobate ($LiNbO_3$), interference occurs when they enter their respective interference detectors due to the uncertainty of the photon paths.

Moreover, this interference will occur at both detectors due to the non-local long-distance interaction of the paired photons (quantum entanglement), even if the distances to the down-converter and each interference detector are different. Consequently, if a laser pulse, which is a collective of photons, is used as the light source, interference fringes will be observed at each interference detector.

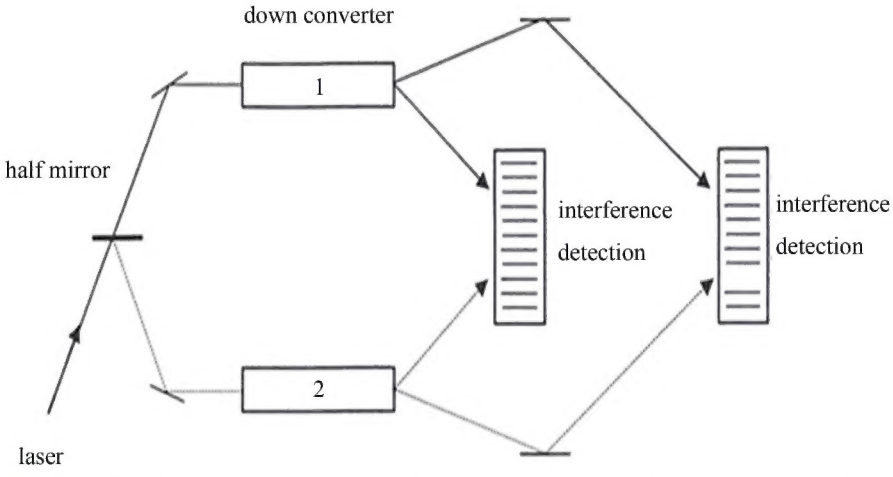

Figure 1. The photon travels along one of the paths on either the left or right through the beamsplitter. This photon then becomes two photons in the down-converter, but since the paths are not determined, interference fringes appear on screens A and B respectively.

Experiment 2

Next, as shown in Figure 2, when observing by replacing one of the interference

detectors with a particle detector, photons that pass through either path via a beamsplitter will be detected by either particle detector (1) or (2). In other words, since the path is determined, only photons from one direction enter the interference detector, and even when a laser pulse is pointed at it, the interference fringes will disappear. This disappearance of interference fringes occurs due to nonlocal long-range interactions (quantum entanglement), even if the particle detector is further away than the interference detector.

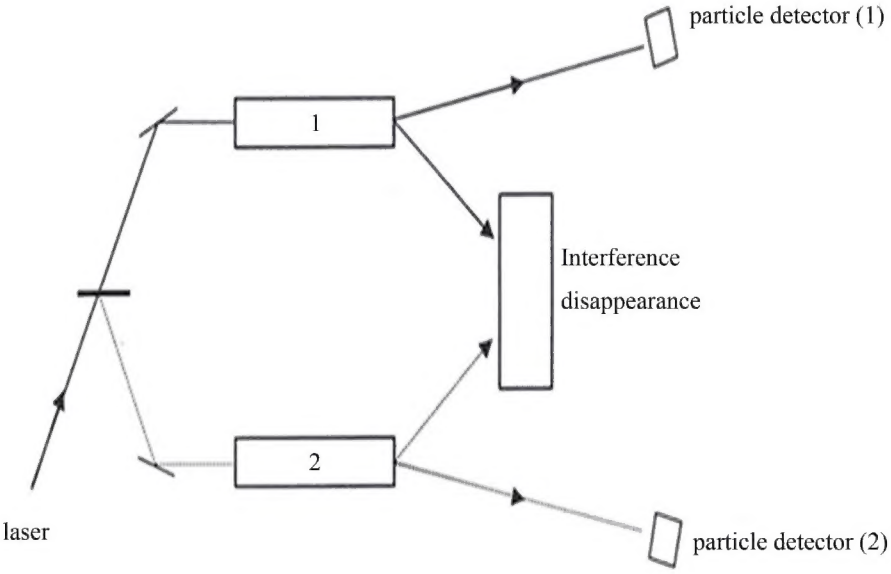

Figure 2. The photon travels along one of the two paths using a half mirror. That photon becomes two photons in the down converter, and since one of those photons is observed in either of the particle detectors, the paths are determined, and no interference pattern is seen on the screen.

Experiment 3

Furthermore, as shown in Figure 3, after setting the photon paths such that interference occurs at both interference detectors, if interference fringes are observed at detector A, the device is configured to immediately remove detector B so that photons can be detected by the particle detector.

The interference detector uses liquid crystal dimming film to prevent vibrations during the removal process. This film becomes opaque when not powered, functioning as an image projection screen, and interference fringes can occur on its surface. However, when this film is powered, it becomes transparent, allowing photons to pass through it and be detected as photons by the particle detector behind it. In the interference detector A, a camera is installed that automatically senses and determines the presence of interference fringes on the screen. Since the image of these interference fringes is the same as those generated in Experiment 1 and Preliminary Experiment 3, the determination is straightforward.

Now, this camera is linked to the electric conduction system of the liquid crystal light modulating film, and when interference fringes are detected, it is immediately energized, making the film transparent. However, there is a delay of 0.1 sec-

onds from the energization to the transparency of the film, so the time for the photons to reach the interference detector B through reflection between the mirrors needs to exceed that. Therefore, it is considered that the installation site for the distant mirror should be a satellite in a geostationary orbit at an altitude of 3600 km.

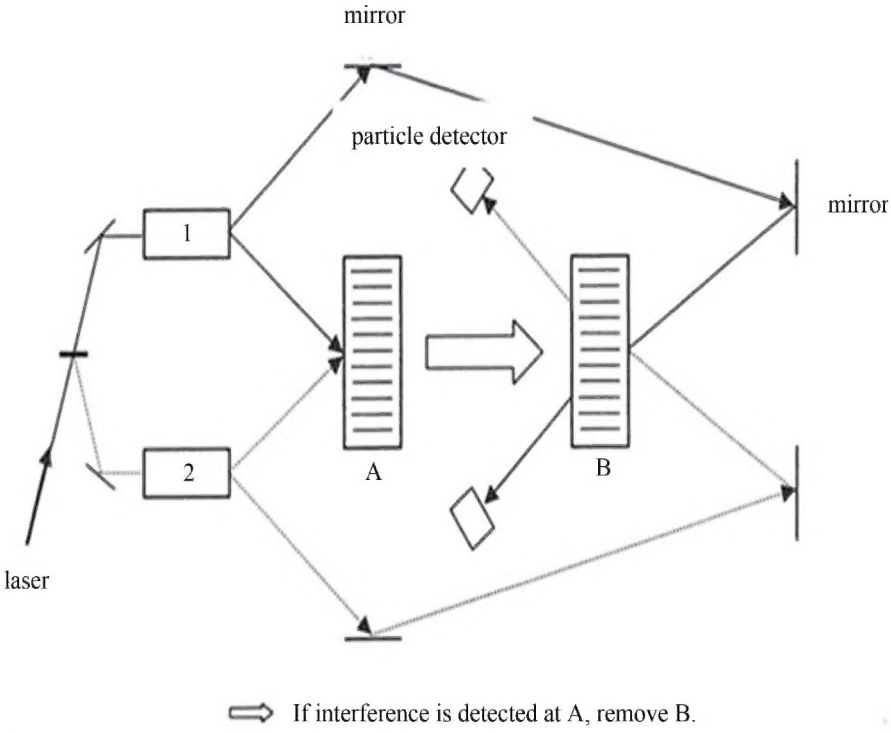

Figure 3. The photon travels along one of the paths to the left or right through a half-mirror. That photon becomes two photons in a down-converter, and if interference fringes are observed on screen A, it means the path of the photon is not determined, so interference fringes will also appear on screen B. However, if screen B is removed immediately after observing the interference fringes on screen A, the photon whose path is not determined will not be observed by either particle detector.

a) In this case, if interference is actually detected at A and the interference detector at B is removed, the photons at B will be observed as particles, resulting in different outcomes for the paired photons, which contradicts the experiment in Figure 2.

b) Furthermore, if no interference is detected at A and the interference detector at B is also not removed, then no interference will occur at the other interference detector either, leading to a contradiction with the experiment in Figure 1. Therefore, simply setting up the interference detector removal device will only yield contradictory results in either case.

c) However, if the mirror is installed on a geostationary satellite, it is possible that particles may not reach the particle detector due to the vibrations and air turbulence caused by the presence of the device in the environment. Therefore, even if interference fringes are detected in A as a preliminary experiment, multiple

experiments will be conducted without performing the interference detector removal operation in B to determine the probability of observing interference fringes in B. By comparing this probability with the particle detection probability after the removal operation of the interference detector in B in the main experiment, the validity of the experiment can be confirmed.

Therefore, simply setting up an interference detection removal device using liquid crystal dimming film can only predict contradictory results either way.

7. Expected Outcome

If there are no contradictions in the experiment, the results of the experiment shown in Figure 3 are expected to be as follows: That is, the interference detector B is not removed due to equipment failure, or for other reasons, the experiment is not conducted.

In other words, while interference fringes can be observed in experiments where the interference detector B is not removed, it has been observed in experiments attempting to remove the interference detector that the probability of detecting particles in either particle detector set in the path of the photons suddenly becomes zero due to an unknown reason attributed to the environment.

This will always yield the same results, no matter how many times it is repeated after confirming that the equipment is functioning normally.

8. Conclusion

In an attempt to explain the phenomenon of quantum entanglement through the Copenhagen interpretation, research on weak measurements has been conducted [22], and quantum decision theory has been proposed [23], but conclusive experimental evidence has not been presented. However, if experiments (1) and (2) are confirmed, and further, if experiment (3) yields the expected results, then the causes of the many attempts that did not result in findings likely involve various phenomena in the macroscopic world that are probabilistically almost impossible, and such anomalous phenomena, as far as we know, do not occur without reason. The attempt to remove the interference detector should have led to some event occurring, which in turn should have caused the strange observational results. Such events might include vibrations from trucks, sudden power outages, earthquakes, atmospheric disturbances, meteorite collisions with satellites, and it is believed that these events occur with each experiment. In other words, there are many branches in the universe where observers exist, and the experimenter can statistically prove this strange fact. Finally, I would like to refer to the paper titled 'The Scientific Method: Upholding the Integrity of Physics' [24], which suggests that attempts to exempt speculative theories of the universe from experimental verification weaken science, as argued by George Ellis and Joe Silk.d.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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